

below normal; the greatest monthly amount, 2.20, occurred at Park City, while none fell at Emery, Green River, and St. George.

Very little farm work was done during the month. Fall grain continues in fair condition. The precipitation west of the Wasatch Mountains was heavy enough to greatly improve conditions on the ranges, but east of these mountains the rainfall was too light to effect any change.—*L. H. Murdoch.*

Virginia.—The mean temperature was 35.7°, or 4.0° below normal; the highest was 75°, at Ashland on the 2d, and the lowest, 14° below zero, at Burkes Garden on the 21st. The average precipitation was 6.45, or 3.66 above normal; the greatest monthly amount, 9.79, occurred at Bigstone Gap, and the least, 2.85, at Birdsnest.

Progress of crops was much retarded by the adverse weather prevailing. The temperatures obtaining were generally below normal, and this, combined with a want of snow protection, was disastrous, especially to late seeded winter wheat, oats, and clover. The early seeded, though injured to some extent, had, as a rule, sufficient root growth to enable it to withstand the worst effects of the freezing weather.—*Edward A. Evans.*

Washington.—The mean temperature was 37.0°, or 0.7° above normal; the highest was 66°, at East Sound on the 5th, and the lowest, 2°, at Northport on the 12th. The average precipitation was 3.81, or 1.84 below normal; the greatest monthly amount, 16.03, occurred at Clearwater, and the least, 0.23, at Ritzville.

Weather mild and open and favorable for growth of winter wheat, although the ground was without snow covering. Early sown wheat is in good condition; that sown in dry soil, during dry weather of October, came up poorly and unevenly, much of it failing to germinate until the rains of November; consequently it is weakly and not in fit condition to withstand severe freezes in the absence of snow covering. With continued open weather it is likely to improve and eventually become strong and vigorous.—*G. N. Salisbury.*

West Virginia.—The mean temperature was 32.3°, or 3.0° below normal; the highest was 75°, at Myra on the 13th, and the lowest, 9°

below zero, at Central Station on the 16th. The average precipitation was 5.84, or 2.81 above normal; the greatest monthly amount, 8.97, occurred at Elkhorn, and the least, 3.57, at Parkersburg.

The weather during the month was very unfavorable for winter wheat, rye, and oats. The seasonable weather of the first part of the month was followed during the third week by severe cold. While wheat was fairly well protected by a good covering of snow it is feared that considerable damage was done. At the close of the month it was generally in very poor condition, and the outlook was not promising. Practically no farm work was done, and some corn yet remained to be husked.—*E. C. Voss.*

Wisconsin.—The mean temperature was 17.7°, or 4.3° below normal; the highest was 57°, at Racine on the 1st, and the lowest, 40° below zero, at Barron on the 13th. The average precipitation was 0.95, or 0.64 below normal; the greatest monthly amount, 2.28, occurred at Osceola, and the least, 0.25, at Antigo.

The most notable feature was the cold wave that overspread the State on the 13th and continued until the 21st. The ground was generally well covered with snow during this period and winter crops escaped injury.—*W. M. Wilson.*

Wyoming.—The mean temperature was 23.4°, or 0.5° below normal; the highest was 75°, at Fort Laramie on the 2d, and the lowest, 41° below zero, at Fort Laramie on the 14th. The average precipitation was 1.34, or 0.63 above normal; the greatest monthly amount, 3.28, occurred at Red Bank, and the least, 0.21, at Laramie.

During the severe storm of the 10th to the 17th several flocks of sheep were scattered in the southern portion of the State and some perished, but the losses were comparatively light. The month, as a whole, was favorable to stock, and practically no losses occurred among the cattle of the State. The heavy snows of the first half of the month provided a good stock of snow in the mountains, and coming early in the season much of it will be conserved for the water supply of next summer.—*W. S. Palmer.*

SPECIAL CONTRIBUTIONS.

EVAPORATION UNDERGROUND.

By EDWIN SWIFT BALCH.

In the MONTHLY WEATHER REVIEW for August and November, 1901, Mr. H. H. Kimball published two valuable papers giving the results of his observations in several *glacières* (or ice caves) in the Appalachians, and also touching at some length on subterranean meteorology. In the National Geographic Magazine for December, 1901, is a note by Mr. W. J. McGee, referring briefly to underground evaporation. A few additional remarks, suggested by these articles, may be of use.

Subterranean meteorology is anything but a new subject, and it has already received a good deal of sporadic attention. As far back, at least, as 1796, Horace Bénédict de Saussure examined a number of cold current caves (breathing caves, blowing caves, or wind holes) in the Alps and the Apennines, and suggested a simple explanation of some of their phenomena. G. F. Parrot, in 1815, also studied the matter carefully. It is probably correct to say that all the scientists who have worked at the phenomena of *glacières* at some length, have examined also more or less into subterranean meteorology, for the reason that the formation of underground ice and the movements of air in caves are an inseparable matter. Among these observers may be mentioned Thury, who, in 1861, divided caves into static and dynamic caves; Browne, in 1865, and in the last twenty-five years, Schwalbe, Martel, and especially Fugger, who devoted fifty pages to "blowing holes" in his book, *Ice Caves and Windholes* (*Eishöhlen und Windröhren*, Salzburg, 1891-1893); the latter is the most important work about *glacières* yet published in German.

Many writers also have recorded their opinions about the possible refrigerating effects of evaporation underground. Among those in the affirmative may be mentioned Pictet, 1822; Scrope, 1827; Reich, 1834; Pleischl, 1841; Murchison, 1845; Olmstead, 1856; Hitchcock, 1861; White, 1870; Kirchhoff, 1876; Krauss, 1895.

In order to get a basis for future observations it may be well to try to formulate the present status of our knowledge of the action of evaporation as a possible factor in the formation of subterranean ice. There seem to be three most noteworthy points:

1. We know positively, from the observations of many good observers, that in many cases subterranean ice is due to the cold of winter.

2. We know almost surely, principally from the observations of Monsieur Martel, that in some cases evaporation lowers the temperatures in caves some 2° to 3° C.

3. We have absolutely no *proof*—only opinions as yet—that evaporation ever produces ice below ground.

The writer's own belief is that in all cases the cold of winter alone is the primary cause of subterranean ice, and that evaporation is practically of no importance in its formation. Our knowledge, however, of the exact effects of evaporation underground is still too limited, and the fact, moreover, that a certain number of scientists have held and that others probably now hold, that evaporation in some cases produces underground ice, emphasizes the need of further observation and experiment.

This problem, of course, can be solved in time. Much patient observation will be necessary, and it may be well to suggest that every observer will probably get more valuable data if he can observe in a certain number of places, rather than in one or two only; at least the writer's experience is that visits to many *glacières* and wind holes is beneficial, by broadening individual knowledge of the subject.

There is another method which may be suggested as a possible help, and that would be to make some experiments in laboratories. So far, de Saussure alone appears to have done anything of the kind. He passed a current of air through a glass tube filled with moistened stones, and found that this air current lost several degrees of heat in its passage. It would seem as though experiments in the same direction ought to afford some useful data.

Although this note is intended to touch on only one point of subterranean meteorology, yet it may be worth adding that the subject is a big one, and that many advances have been made in it in the last few years. It is only recently, for instance, that it has been recognized that the temperature of caves is not always the same throughout. There are many other such points which need elucidation, and the interest shown by the Weather Bureau is a welcome help to speleologists, and warrants the hope that further systematic observations and experiments will be made and more attention now be given to everything connected with the atmosphere underground.

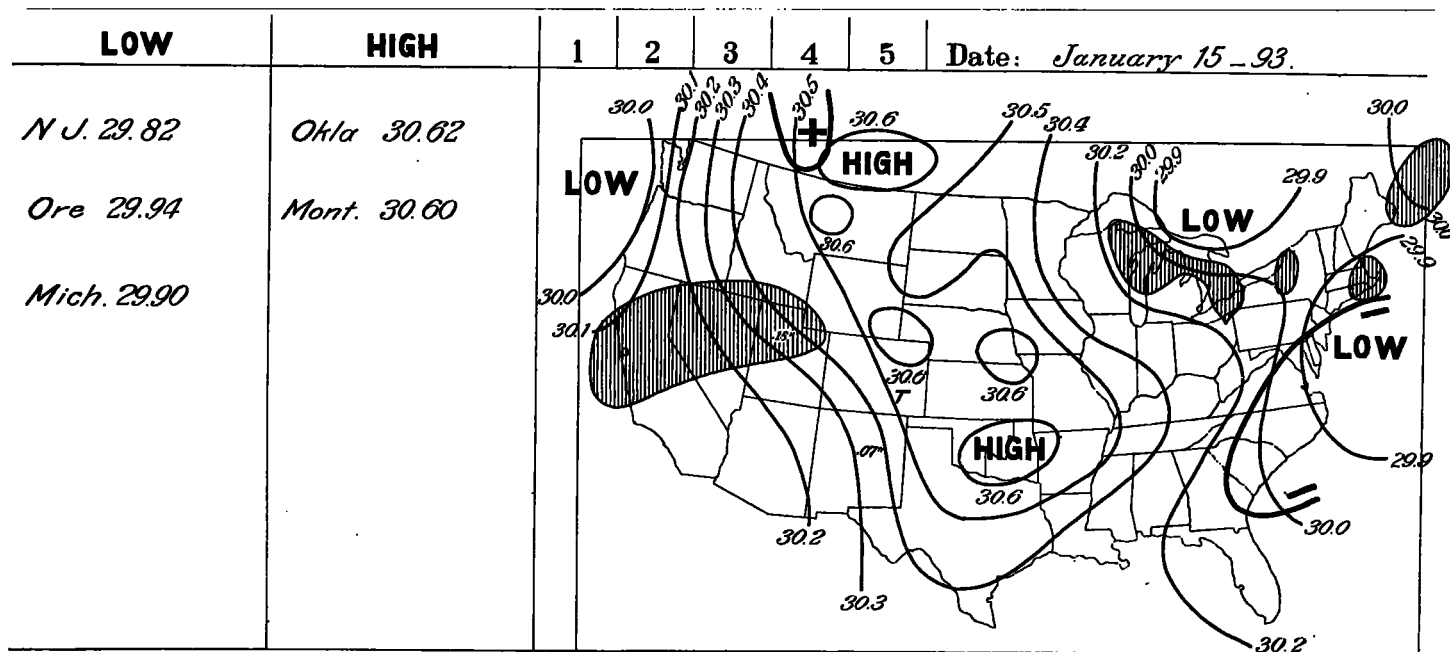
FACILITIES FOR SYSTEMATIC STUDY OF CORRESPONDING WEATHER TYPES.¹

By F. H. BRANDENBURG, Forecast Official, Denver, Colo.

During the summer of 1900, it was my privilege to spend a short time in the Forecast Division of the Central Office, and in making practise forecasts for the whole United States I often felt the need of "type maps," similar to the current map, available for reference. It is needless to say that in searching for these much time was consumed without satisfactory results, and this caused me to consider seriously the matter of devising some method of classifying maps according to type. Consultation with Professor Garriott encouraged me to undertake the work, and on my return to station, plans were formulated for a system of ready reference to all weather types shown by the morning maps issued by the Central Office during the past ten years.

quickly refreshing the memory as to the different conditions and types that obtain during any particular month.

The size of the original maps precludes their use, and a small base map of the United States was therefore drawn and printed on half sheets of letter paper, as shown in fig. 1, a space being reserved on the left for notations. This space is divided into two columns, at the top of which the words "high" and "low," respectively, are printed on one set, while on the other set the words of the heading are reversed. As regards the lines to be reproduced, a sketch of the principal isobars, with the regions of high and low pressure suitably marked, was considered sufficient. The period covered being about ten years, thirty-six or thirty-seven hundred maps were sketched. These sketches were duplicated by means of carbon paper, the number of duplicates for each date depending upon the number of highs and lows on the map that were considered valuable in the classification. In some instances one map was sufficient for the set of high areas and one for the set of low areas, but occasionally as many as eight in all were necessary; in general four sufficed. The next step was to outline on each small map the shaded or rainfall areas shown on the Washington map of the succeeding day. By shading these areas with a green pencil we avoid interfering with the isobars, which are drawn in red. Thunderstorms are indicated by a small green cross, and the regions visited by temperature changes of 20° are outlined in black. Mention has been made of two columns on each sheet at the left of the map. In the appropriate column an entry is made showing the location of the high and the low areas. Each of the different entries is given first place on some one map, and the dis-



Remarks:

+ = rise of 20° or more next morning.

- = fall of 20° or more next morning.

Figures represent Rainfall in this Forecast District during 12 hours ending 5 p.m. to morrow

FIG. 1.—Sample map for classified file.

My purpose in bringing this subject to your attention is not to lay down any procedure for study but merely to describe facilities which it is believed will prove a valuable aid in

¹ Read before the Milwaukee Convention of Weather Bureau Officials, August 28, 1901.

tribution of the maps is made in accordance with this entry. Every map thus made finds a place in some one of the ten or eleven districts adopted. For example, let us take the high areas for January. A map for each date on which such an area occupied the British Northwest Territory will be found